

DOCUMENT RESUME

ED 071 912

SE 015 549

TITLE Project Physics Programmed Instruction, Vectors 1.
INSTITUTION Harvard Univ., Cambridge, Mass. Harvard Project
Physics.
BUREAU NO BR-5-1038
PUB DATE 68
NOTE 56p.
EDRS PRICE MF-\$0.65 HC-\$3.29
DESCRIPTORS Individualized Instruction; *Instructional Materials;
Mathematical Applications; Mathematics; *Physics;
*Programed Instruction; Science Education; *Secondary
School Science
IDENTIFIERS Harvard Project Physics; *Vectors

ABSTRACT

This programmed instruction booklet is an interim version of instructional materials being developed by Harvard Project Physics. It is the first in a series of three booklets on vectors and covers the definitions of vectors and scalars, drawing vector quantities to scale, and negative vectors. For others in this series, see SE 015 550 and SE 015 551. (DT)

FILMED FROM BEST AVAILABLE COPY

ED 071912

Project Physics Programmed Instruction

DE 015 549

U.S. DEPARTMENT OF HEALTH,
EDUCATION & WELFARE
OFFICE OF EDUCATION
THIS DOCUMENT HAS BEEN REPRO-
DUCED EXACTLY AS RECEIVED FROM
THE PERSON OR ORGANIZATION ORIG-
INATING IT. POINTS OF VIEW OR OPIN-
IONS STATED DO NOT NECESSARILY
REPRESENT OFFICIAL OFFICE OF EDU-
CATION POSITION OR POLICY

Vectors¹



FILMED FROM BEST AVAILABLE COPY

This programmed instruction booklet is the authorized interim version of one of the many instructional materials being developed by Harvard Project Physics, including text units, laboratory experiments, and teacher guides. Its development has profited from the help (showing of the catalogue lists) at the front of the text units.

Copyright © 1968, Project Physics Incorporated.

Copyright (continued until September 3, 1968). After September 3, 1968, all portions of this work are identified herein as the subject of public domain copyright and the public domain. The authorized interim version of the Harvard Project Physics course (being distributed until by Holt, Rinehart and Winston, Inc.) is in agreement with Project Physics Incorporated, a nonprofit educational organization.

All unauthorized copies of any part of this material must be reported to the following: the source and the financial support given to Project Physics by the agencies named below, and by include a statement that the publication of unauthorized copies is not authorized by Harvard Project Physics or any of the authors of this work.

The work of Harvard Project Physics has been generously supported by the Committee on Science at New York University, the National Science Foundation, the Alfred P. Sloan Foundation, the United States Office of Education and Harvard University.

Authorized Interim Version  1968-69

Distributed by Holt, Rinehart and Winston, Inc. New York Toronto

03-073465-7

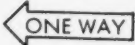
0123 69 9876543

FILMED FROM BEST AVAILABLE COPY

INTRODUCTION

You are about to use a programmed text. You should try to use this booklet where there are no distractions—a quiet classroom or a study area at home, for instance. Do not hesitate to seek help if you do not understand some problem. Programmed texts require your active participation and are designed to challenge you to some degree. Their sole purpose is to teach, not to quiz you.

Vectors 1 The Concept of Vectors

You are familiar with signs such as  that indicate a direction. You have also seen signs which give a magnitude such as

SPEED
50
LIMIT

OR

MAXIMUM
35 TONS
CAPACITY

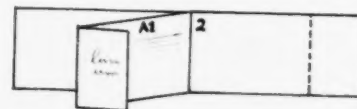
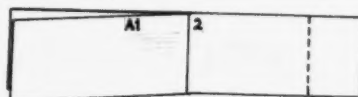
This program is about quantities that have both a direction and a numerical value. These are called vectors and they are very important in physics.

You are already familiar with some examples of vectors. This part of the program will start with these examples.

FILMED FROM BEST AVAILABLE COPY

INSTRUCTIONS

1. Frames: Each frame contains a question. Answer the question by writing in the blank space next to the frame. Frames are numbered 1, 2, 3, ...
2. Answer Blocks: To find an answer to a frame, turn the page. Answer blocks are numbered A1, A2, A3, ...
This booklet is designed so that you can compare your answer with the given answer by folding back the page, like this:



3. Always write your answer before you look at the given answer.
4. If you get the right answers to the sample questions, you do not have to complete the program.

FILMED FROM BEST AVAILABLE COPY

Sample Question A

Complete this sentence if you can:

A scalar quantity can be expressed by (i) _____, but a vector quantity must be expressed by both (ii) _____.

Answer Space

FILMED FROM BEST AVAILABLE COPY

Answer to A

- (i) a number (with or without units)
- (ii) a number (with or without units)
and a direction.

FILMED FROM BEST AVAILABLE COPY

Sample Question B

It is important to be able to distinguish between vector and scalar quantities in equations.

- (i) List all of the vector quantities in the equation

$$\vec{T} = m \vec{a} + 6 \vec{P}.$$

- (ii) List all of the scalar quantities in the same equation.

Answer Space

FILMED FROM BEST AVAILABLE COPY

Answer to B

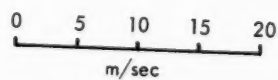
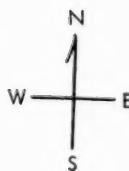
(i) $\vec{T}$, $\vec{a}$, and $\vec{P}$

(ii) m and 6

FILMED FROM BEST AVAILABLE COPY

Sample Question C

Suppose the wind is blowing from the northeast at 12 m/sec. Draw an arrow that represents this wind velocity to the scale given.



Answer Space

FILMED FROM BEST AVAILABLE COPY

Answer to C

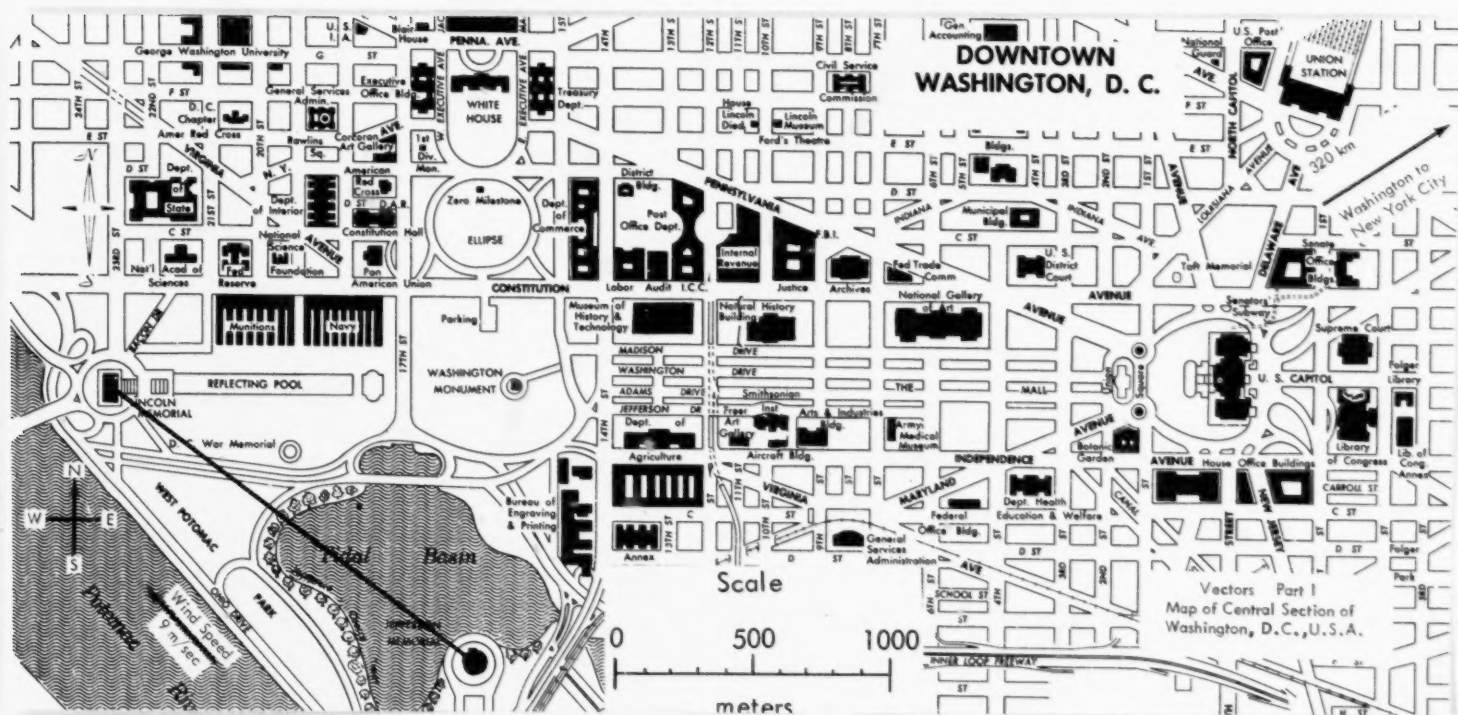


wind velocity
12 m/sec

If you answered all 3 sample questions correctly, you are ready for the Vectors 2 program.

If not, begin with question 1 on the next page.

FILMED FROM BEST AVAILABLE COPY



FILMED FROM BEST AVAILABLE COPY

1

Questions 1 through 15 require a map of Washington, D.C., which is provided with the booklet.

Find the location of the Lincoln Memorial and the Jefferson Memorial on the map of Washington, D.C. A straight line is shown between the memorials. According to the scale on the map, the distance between the Lincoln and Jefferson Memorials is _____ meters.

(Hint: One way to use the scale on the map is to copy it off the edge of a piece of paper which can be placed along any line you wish to measure.)

FILMED FROM BEST AVAILABLE COPY

A1

about 1700 meters, measuring
center to center

FILMED FROM BEST AVAILABLE COPY

2

From the compass directions on the map we can see that the Jefferson Memorial is located 1700 meters _____ of the Lincoln Memorial.

FILMED FROM BEST AVAILABLE COPY

A2

southeast

FILMED FROM BEST AVAILABLE COPY

3

Locate the White House, and find the distance and direction of the White House from the Jefferson Memorial.

FILMED FROM BEST AVAILABLE COPY

A3

approximately 2100 meters to the north

FILMED FROM BEST AVAILABLE COPY

4

One of the important concepts of physics is that of displacement, which is the straight line distance between the initial and final locations of an object. Use the map of Washington, D.C., to answer the following questions:

- (i) What building will you reach if you start at the Washington Monument and travel 2600 meters due east?
- (ii) What was your displacement?

FILMED FROM BEST AVAILABLE COPY

A4

- (i) the U.S. capitol
- (ii) 2600 m east from the Washington Monument

FILMED FROM BEST AVAILABLE COPY

5

- (i) What would be your displacement if you traveled from the Capitol to the White House?
- (ii) What is the displacement if something is moved from the White House to the Washington Monument?

FILMED FROM BEST AVAILABLE COPY

A5

- (i) 2900 m, approximately northwest
(actually 290° from north)
- (ii) 1100 m south (actually slightly east
of south)

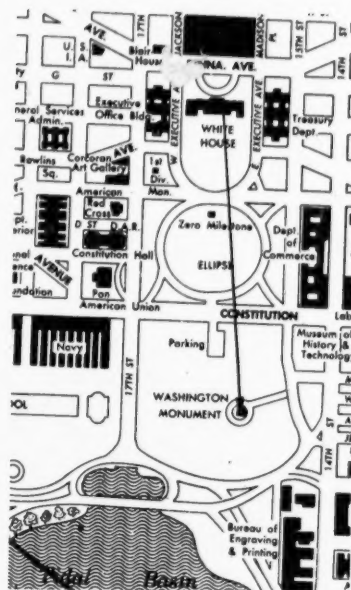
FILMED FROM BEST AVAILABLE COPY

6

A displacement can be represented by an arrow on a map. The length of the arrow represents a scale drawing of the actual displacement.

(i) What displacement is shown?

(ii) Draw the arrow on your map of Washington that can represent the displacement from the Washington Monument to the Capitol.

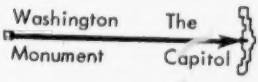


FILMED FROM BEST AVAILABLE COPY

A6

(i) White House to Washington Monument
(1100 m south)

(ii) Washington Monument The Capitol



FILMED FROM BEST AVAILABLE COPY

7

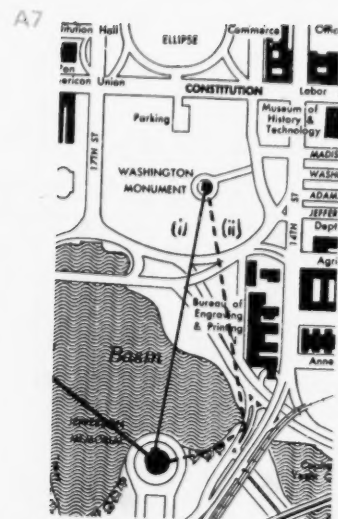
(i) Draw an arrow on the map to represent the displacement of a person who has walked from the Washington Monument to the Jefferson Memorial.

(ii) Draw on the map the shortest path for walking on dry ground from the Washington Monument to the Jefferson Memorial.

(iii) Does the choice of path change the displacement?

FILMED FROM BEST AVAILABLE COPY

(iii) no (it changes the path length, but not the displacement, which is defined as the straight-line distance.)



FILMED FROM BEST AVAILABLE COPY

8

On the map of Washington, D.C., there is an arrow which indicates that the displacement of New York City from Washington is
distance? direction?

FILMED FROM BEST AVAILABLE COPY

A8

320 km northeast

FILMED FROM BEST AVAILABLE COPY

9

Note that the distance scale at the bottom of the map is for measurements inside Washington, and the displacement to more remote places such as New York City is represented with another scale. It is not essential that the arrow representing a displacement vector be drawn to the same scale as the map.

Pittsburgh, Pennsylvania, is approximately 320 kilometers to the northwest of Washington. Draw near the top of the map the arrow by which you can represent this displacement.

(Use the same scale as the arrow showing the displacement of New York City.)

FILMED FROM BEST AVAILABLE COPY

A9

320 km
Washington, D.C. to
Pittsburgh, Pa.

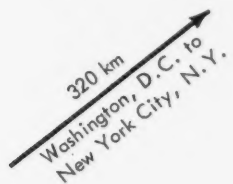
FILMED FROM BEST AVAILABLE COPY

10

Quantities that have both magnitude and direction are called vectors.

Quantities that have a magnitude but no direction are called scalars.

Is the displacement shown below a scalar or a vector?



FILMED FROM BEST AVAILABLE COPY

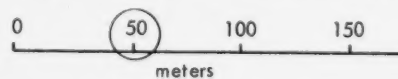
A10

vector

FILMED FROM BEST AVAILABLE COPY

11

Quantities that have only a magnitude are called scalars. Those quantities that have both magnitude and direction are called vectors.



Is the position of the 50 meter mark on the scale a vector or a scalar?

FILMED FROM BEST AVAILABLE COPY

A11

scalar

FILMED FROM BEST AVAILABLE COPY

12

A scalar quantity can be expressed by a single number (with or without units), but a vector must have both _____ .

FILMED FROM BEST AVAILABLE COPY

A12

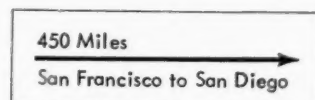
magnitude and direction

FILMED FROM BEST AVAILABLE COPY

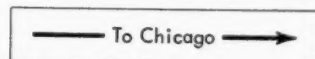
13

Are the following pictures representations of vectors, of scalars, or of neither?

(i)



(ii)



FILMED FROM BEST AVAILABLE COPY

A13

(i) vector (a displacement)

(ii) neither (only direction)

FILMED FROM BEST AVAILABLE COPY

14

On the map of Washington, D.C., there is an arrow representing the wind velocity. The arrow indicates that the wind is blowing from the (i) _____ at a speed of (ii) _____.

FILMED FROM BEST AVAILABLE COPY

A14

(i) southeast

(ii) 9 m/sec (about 20 miles/hr)

FILMED FROM BEST AVAILABLE COPY

15

The speed and direction of the wind is a vector quantity, and therefore it can be represented by an arrow drawn to scale. Suppose the wind changed and is now coming from the west at 18 m/sec.

On the map, draw the new wind direction, and indicate the new wind speed by making the arrow of the proper length (using the other wind arrow as a guide).

FILMED FROM BEST AVAILABLE COPY

A15

wind speed = 18 m/sec



(This is twice as long as the length shown
for a wind speed of 9 m/sec.)

FILMED FROM BEST AVAILABLE COPY

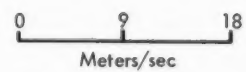
16

- (i) Use the wind vector shown on the map to draw a scale for the wind speed.
- (ii) What is the length of the arrow needed to represent a wind speed of 27 meters/sec?

FILMED FROM BEST AVAILABLE COPY

A16

(i) Scale



(ii) three times the length for 9m/sec

FILMED FROM BEST AVAILABLE COPY

17

Whenever we encounter a physical quantity--such as speed, force, energy, or whatever--it is useful for us to know whether or not it involves direction. Those quantities that involve direction as well as magnitude are called

(i) _____.

(ii) Does the pull each team exerts on the rope in the tug-of-war involve a direction?



Photo G. Kew, LIFE MAGAZINE, © Time Inc.

FILMED FROM BEST AVAILABLE COPY

A17

(i) vectors

(ii) yes

FILMED FROM BEST AVAILABLE COPY

18

18. When we encounter a physical quantity that is a scalar we mean it has no

(i) _____ .

(ii) Is the diameter of the water wheel shown here a vector or a scalar?



Photo C. W. Kirkland,
LIFE MAGAZINE, © Time Inc.

FILMED FROM BEST AVAILABLE COPY

A18

(i) direction

(ii) scalar

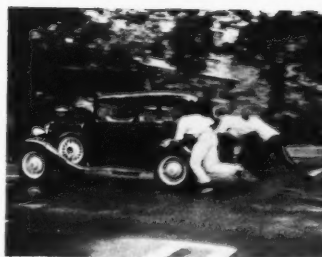
FILMED FROM BEST AVAILABLE COPY

19

Four boys are shown pushing a car. The force each boy exerts on the car is a

(i) _____ quantity, and the number

of boys pushing the car is a (ii) _____ quantity.



FILMED FROM BEST AVAILABLE COPY

A19

(i) vector

(ii) scalar

FILMED FROM BEST AVAILABLE COPY

20

When writing one usually draws a small arrow over the symbol used for vector quantities. For example, in the equation

$$\vec{F} = m \vec{a},$$

$\vec{F}$ represents a vector quantity, the force, and $\vec{a}$ represents an acceleration in the same direction as $\vec{F}$. The letter m represents a scalar, mass.

(i) List all vector quantities in the equation

$$\vec{T} = m \vec{a} + 6 \vec{N}$$

(ii) List all of the scalar quantities in the same equation.

FILMED FROM BEST AVAILABLE COPY

A20

(i) $\vec{T}$, $\vec{a}$, $\vec{N}$

(Did you put the arrows over the symbols?)

(ii) m , 6

FILMED FROM BEST AVAILABLE COPY

21

The negative of a vector quantity is represented by an arrow in the reverse direction. For example if $\vec{A}$ is represented by $\vec{A}$ then $-\vec{A}$ is represented by $-\vec{A}$

If $\vec{B}$ is $\vec{B}$ 5 units, draw $-\vec{B}$.

FILMED FROM BEST AVAILABLE COPY

A21



FILMED FROM BEST AVAILABLE COPY

22

If $\bar{C}$ is

give a full label to:

FILMED FROM BEST AVAILABLE COPY

A22

"C"

FILMED FROM BEST AVAILABLE COPY

23

This ends Vectors 1.

You have learned to distinguish between vectors and scalars. You have drawn vector quantities to scale, and you have learned that a negative vector is in the opposite direction from the corresponding positive vector.

You are now ready to learn to add vector quantities. See the program booklet Vectors 2.